Resource Allocation Planning and Scheduling Office

70 Meter Life-Extension Downtime Assessment Report

March 21, 2003

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Study Description

This report describes a feasibility study that was conducted to support the DSN 70-meter life-extension project proposal. The study's main objectives are to determine possible refurbishment downtimes for the DSN's three 70-meter antennas and to answer questions with respect to any recommended downtime windows for each antenna. These questions are:

1. Can the 70-meter life-extension effort be accommodated with the projected tracking loads and critical events as they are known today?

2. Will alternate assets be required when a 70-meter antenna is down for refurbishment?

3. Is there alternatives to taking an antenna down for a single long period of time to do the refurbishment (i.e., could the life-extension effort be done in smaller increments of downtime over a greater length of linear time that would have less impact on 70-meter availability)?

Members of the RAPSO met with members of the 70-meter life-extension project to arrive at workable 70-meter downtime windows that accommodate not only the 70-meter life-extension project, but also the DSN 70-meter subnet users. No cost determinations were required in the study.

Constraints

Several constraints exist on when any of the 70-meter antennas can be taken down. The most severe constraints are the tracking requirements imposed by Cassini.

Cassini, in an effort to control costs, has tracking requirements into 2008 for which sequences have already been developed. To change these sequences would be difficult and costly, and as a result, RAPSO has agreed to honor their requirement and propose downtimes for the 70-meter life-extension project that do not impact or minimize the impact on their plans.

Critical events, by-and-large, impose restrictions that may prevent taking down an antenna. In general, launch support does not require a 70-meter antenna even though launches are depicted on the charts that follow. Additionally, some Projects, like New Horizons, require continuous 70-meter coverage during different phases of their mission such as New Horizons Jupiter flyby. These are also depicted on the charts that follow.

Finally, loads represent a constraint in the sense that tracking requirements might not be met even with Project agreed to reductions if an antenna is down. In this case, an alternate asset may be

required. One period, weeks 36 through week 39 of 2007 represents a period of concern. In this period, the 34-meter subnets are heavily loaded and originally RAPSO considered moving some of the load up to the 70-meter subnet. However, on analysis, it is believed that these loads can be accommodated on the 34-meter subnets if MSPA is maximized during the period (up to 3 or 4-SPA as needed for Mars missions at Mars) and some reductions of Ground Based Radio Astronomy (GBRA) tracking requirements and extended missions tracking requirements are agreed to.

Approach and Assumptions

The approach taken in the study was to analyze the tracking load on each antenna taking into account critical events, load, Cassini tracking, and periods of high interest such as the Mars view. A model of each antenna's tracking requirements was developed for the periods 2005 thru 2008, and for 2009 thru 2012. Only the model for 2005 thru 2008 will be discussed in this report.

The charts created by the model have the following assumptions:

- The charts have resolution to the week
- Tracking requirements were allocated for all missions by complete user requested tracks and duration, and by antenna requested as allowed for by mission view periods at each antenna. If the user tracking requirements requested, for example, 70-meter support instead of a specific 70-meter antenna, then the tracks were distributed evenly to each of the three 70-meter antennas, view periods permitting.
- No ESA, CNES, or ASI support at Canberra is assumed (i.e., no tracking support included for Venus Explorer, Bepi Colombo, Herschel, and Planck at DSS-43).
- Tracking requirements are the February 21, 2003 RAPSO database updated with changes from the February 11, 2003 RARB.
- The only MSPA included is that agreed to at the February 11, 2003 RARB between Mars 2001 Odyssey and Mars Global Surveyor, and between Mars 2001 Odyssey and Mars Express Orbiter.

Following the generation of the charts, the group analyzed the life-extension project's downtime requirements against the loads and critical events, identifying possible downtime windows for each antenna. Based upon those choices, example downtimes were chosen and the model was rerun distributing the loads to the remaining two 70-meter antennas and assessing whether the redistribution of the loads could be accommodated and whether they represented an unreasonable load increase and an alternate asset would be needed.

Finally, the downtime requirements of the refurbishment tasks were looked at and it became apparent that if the tasks in the refurbishment project were done sequentially, a total of 156 weeks (or 3 years worst case) would be required to refurbish each antenna. However, since much of the work proposed can be done in parallel, the 70-meter life-extension project asserted that refurbishment of an antenna could be done in 26 to 30 weeks (roughly 6 months) in one contiguous downtime.

Assessment

Goldstone DSS-14 Loading - 2005 Thru 2008

Figure 1 shows the forecasted total tracking load requested in hours for each week (black for non-Mars Missions and gray for Mars Missions) on DSS-14 from January 1, 2005 through December 31, 2008. The blue bar indicates the maximum hours in a week (168 hours). Critical support events denoted in white (and some in red) in the black area are charted where DSS-14 support is either required or may be required. The Mars view from DSS-14 is depicted with a heavy red line

throughout the four year period. White diamond tipped lines in the black area denote periods where Mars view from DSS-14 drops below 10 hours/day.

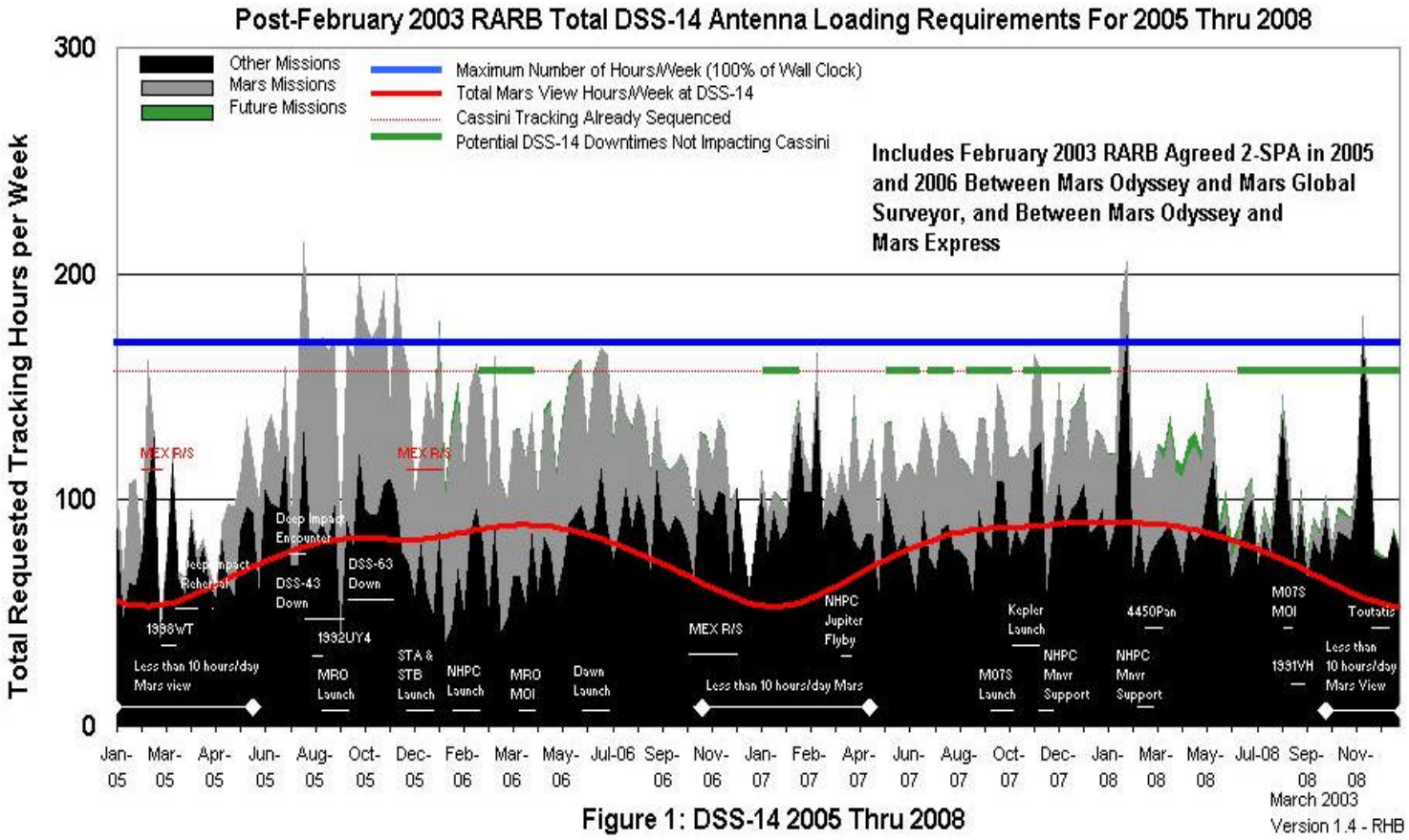

Figure 1: DSS-14 2005 Thru 2008

Cassini tracking requirements for which sequencing has been developed and would be difficult to change are identified by light dotted red lines that connect to heavier dark green lines. The heavier green lines are where Cassini has no tracking requirements and/or sequences established. These represent potential windows of opportunity for taking down DSS-14 for performing refurbishment tasks.

Canberra DSS-43 Loading - 2005 Thru 2008

Figure 2 shows the forecasted total tracking load requested in hours for each week (black for non-Mars Missions and gray for Mars Missions) on DSS-43 at Canberra from January 1, 2005 through December 31, 2008. Like with Figure 1, Figure 2 depicts the maximum hours in a week (168 hours) with a heavy blue line. Critical support events are again denoted in white (and some in red) in the black area as was charted for DSS-14. Again, support is either required or may be required by these critical events. The Mars view from DSS-43 is a heavy red line and the white diamond tipped lines in the black area denote periods where Mars view from DSS-43 drops below 10 hours/day.

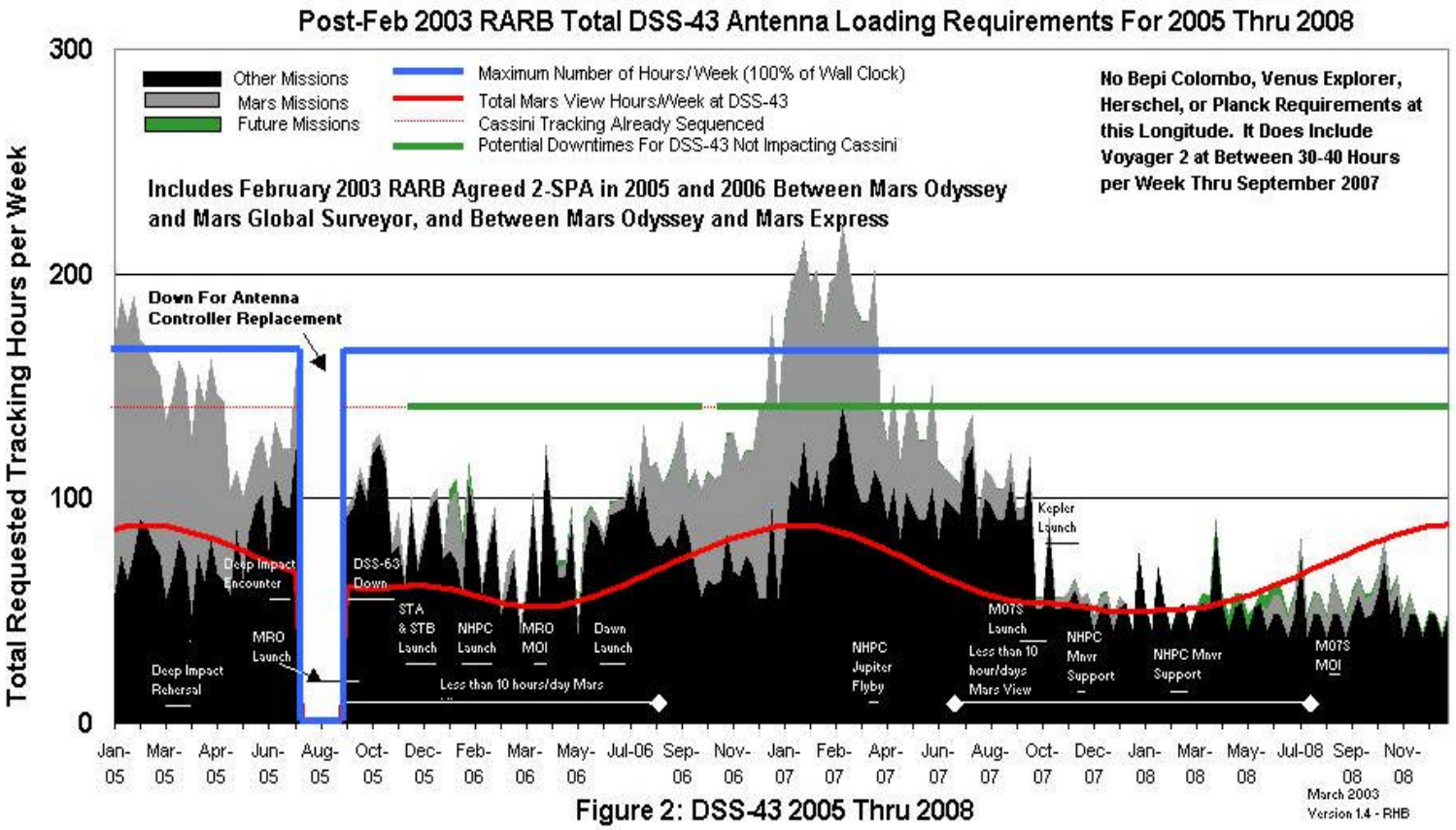

Figure 2: DSS-43 2005 Thru 2008

As in Figure 1, Cassini tracking requirements for which sequencing has been developed and would be difficult to change are identified by light dotted red lines that connect to heavier dark green lines. These heavier green lines, as before, are where Cassini has no tracking requirements and/or sequences established. These represent potential windows of opportunity for taking down DSS-43 for performing refurbishment tasks.

The extensive overload depicted at DSS-43 from January 2007 through April 2007 does not take any MSPA into account for missions at Mars since none have been agreed to at this time. It is believed through the RARB process that MSPA (up to 3 or 4SPA) during this period will substantially reduce the apparent overload. Additionally, full Voyager 2 tracking requirements are in the database and these can be reduced substantially to accommodate the tracking requirements during these weeks.

Madrid DSS-63 Loading - 2005 Thru 2008

As in Figure 1 and 2, Figure 3 shows the forecasted total tracking load requested in hours for each week (black for non-Mars Missions and gray for Mars Missions) on DSS-63 at Madrid from January 1, 2005 through December 31, 2008. Like with Figure 1 and 2, Figure 3 depicts the maximum hours in a week (168 hours) with a heavy blue line. Critical support events are again denoted in white (and some in red) in the black area as was charted for DSS-14 and DSS-43. Again, support is either required or may be required by these critical events. The Mars view from DSS-63 is again a heavy red line and the white diamond tipped lines in the black area denote periods where Mars view from DSS-63 drops below 10 hours/day.

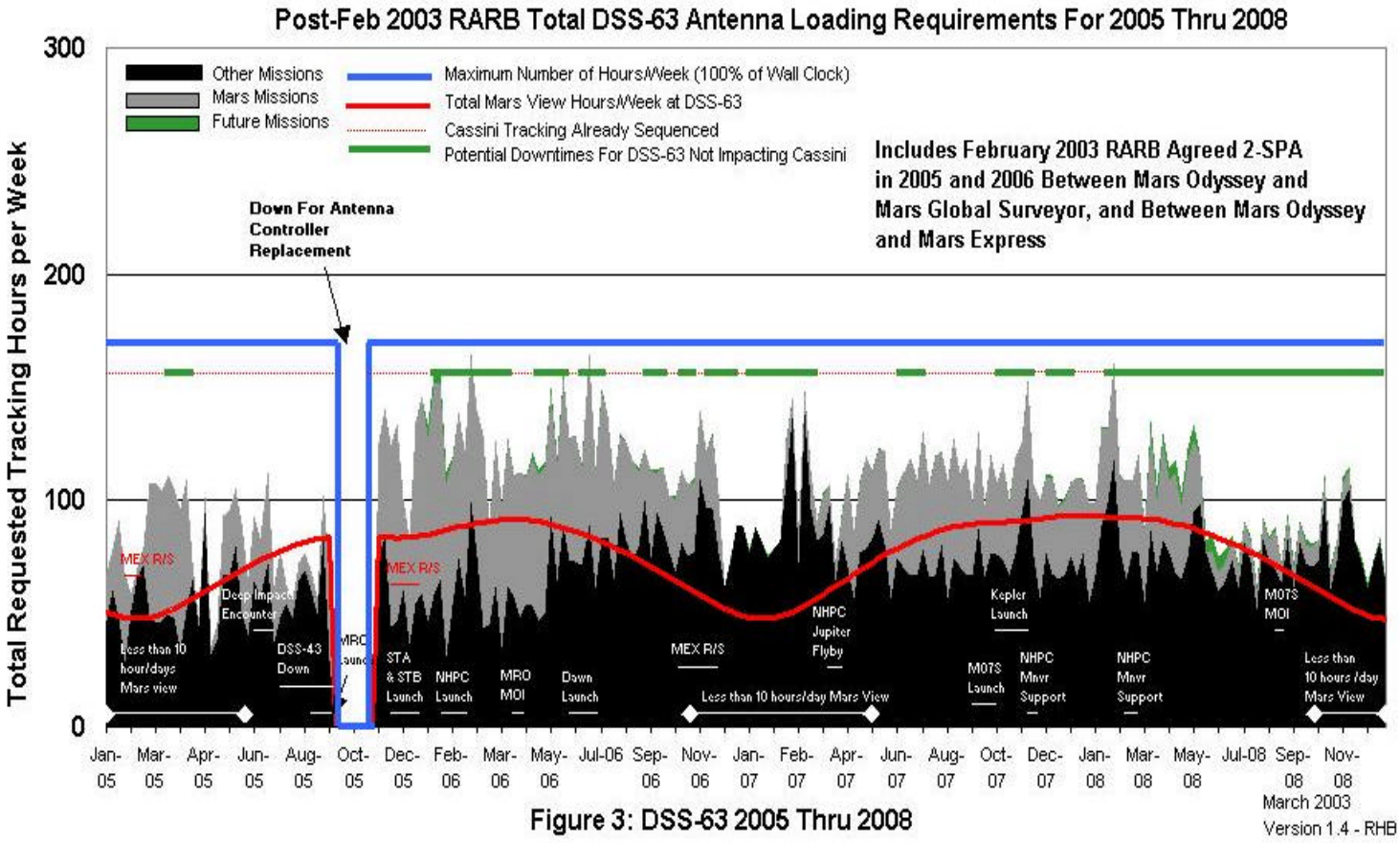

Figure 3: DSS-63 2005 Thru 2008

As in Figure 1 and 2, Cassini tracking requirements for which sequencing has been developed and would be difficult to change are identified by light dotted red lines that connect to heavier dark green lines. These heavier green lines, as before, are where Cassini has no tracking requirements and/or sequences established. These represent potential windows of opportunity for taking down DSS-63 for performing refurbishment tasks.

Downtime Analyses

Goldstone DSS-14 Refurbishment Downtime - 2007

Using the requested 6-month downtime recommended earlier under '**Approach and Assumptions**' as the basis of selecting possible windows for taking DSS-14 down for refurbishment, two periods exist wherein it may be conceivable to remove DSS-14 from service (load permitting). The heavy green dashed line in Figure 4 from May 29, 2008 thru December 31, 2008, or earlier from April 25, 2007 through December 31, 2007 present themselves. Either period is a possible window for taking DSS-14 down, except that the earlier period is only possible if Cassini would accept arraying four 34-meter antennas at Goldstone in place of DSS-14 for their tracking requirements. The later period too, would preclude downtime for DSS-63 in the period 2005 thru 2008 and would push a downtime for it out into 2009 or later. The days that four 34-meter antennas would be needed by Cassini are June 12, 2007, July 21, 2007, and September 30, 2007.

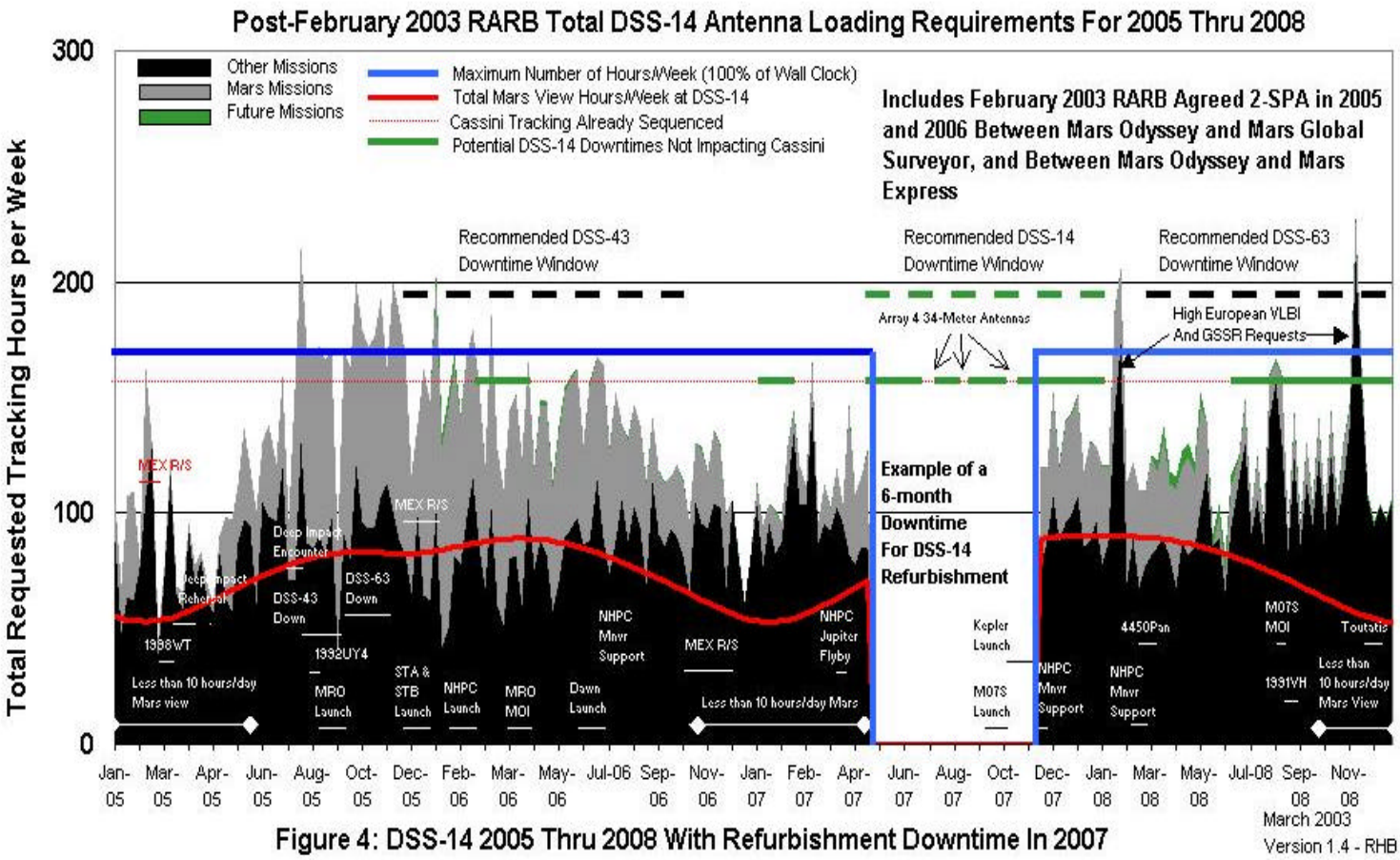

Figure 4: DSS-14 2005 Thru 2008 With Refurbishment Downtime In 2007

In Figure 4, the example downtime for DSS-14 refurbishment is shown for the earlier period. Also, Figure 4 shows the increased loads on DSS-14 from the example downtimes for the recommended windows for DSS-43 and DSS-63 too. Based upon this 'what-if', it appears that the recommended window for refurbishing DSS-14 is doable provided Cassini accepts the use of four 34-meter stations at Goldstone for the three days they have sequences already developed.

Canberra DSS-43 Refurbishment Downtime – 2005-2006

Using the same approach as taken with DSS-14, the period starting from November 7, 2005 through September 14, 2006 was chosen as a possible window for refurbishing DSS-43. Figure 2 depicts that example 6-month downtime as well as the increased loads at DSS-43 as a result of the example downtimes in the recommended windows for DSS-14 and DSS-63.

This window was selected for DSS-43 because Cassini has no sequences developed for DSS-43 in this period and Mars view is less than 10 hours per day. However, Mars Reconnaissance Orbiter (MRO) undergoes orbit insertion during this window (day 69 of the second week of March in 2006) and the project has requested continuous 70-meter support on day 69 of 2006. Since both DSS-14 and DSS-63 have Mars view in excess of 13 hours, it was determined that nearly 21 hours of the requested 24-hour coverage can be provided by these other two 70-meter antennas and the remaining 3 hours could be provided by a Goldstone 34-meter antenna if the Project approves and the downtime for DSS-43 occurs in this period.

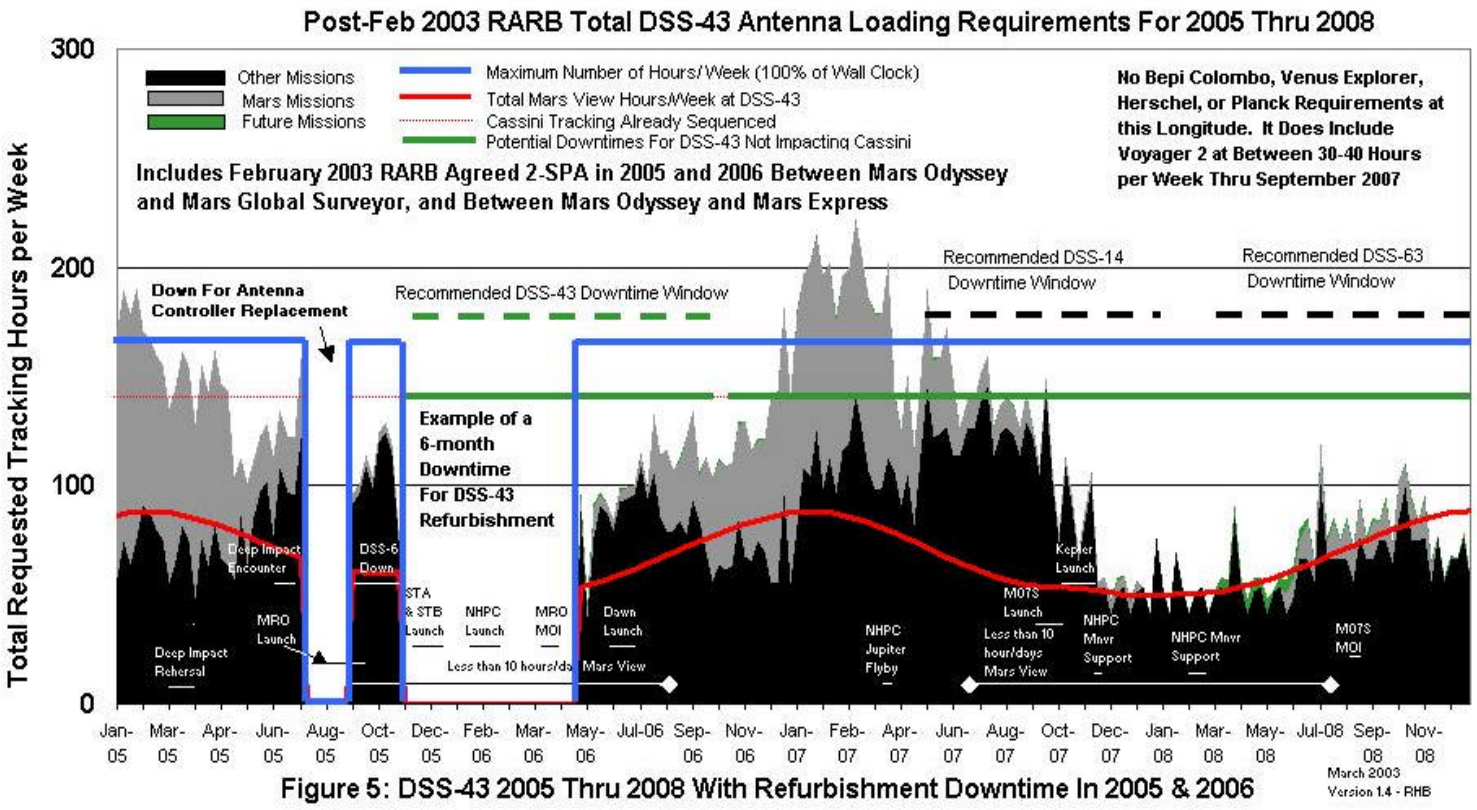

Figure 5: DSS-43 2005 Thru 2008 With Refurbishment Downtime In 2005 & 2006

Also, during this period, Cluster has tracking requirements for arraying all four antennas at Canberra. In the past, this project has agreed to removable of an antenna from their arraying requirements, and there is no reason not to believe they will agree to removing DSS-43 from the array during this time if the DSS-43 downtime occurs here.

Assuming MRO approves the recommendation, then the recommended window appears doable.

Madrid DSS-63 Refurbishment Downtime – 2008

Following the same pattern as was done with DSS-14 and DSS-43, a downtime window for DSS-63 is doable in the last half of 2008 from week 26 (June 23, 2008) through week 52 (December 31, 2008). As with MRO, there is an orbit insertion for a place holder generic Mars mission that represents a possible scenario for the competed Mars 07 Scout. If an orbit insertion occurs with the winning Scout mission in this time period, it is assumed to be able to accommodate the example DSS-63 downtime simply because Mars view from Madrid is dropping and will be nearly below 10 hours per day at this time, and any coverage requirement will be handled in a similar fashion as for MRO.

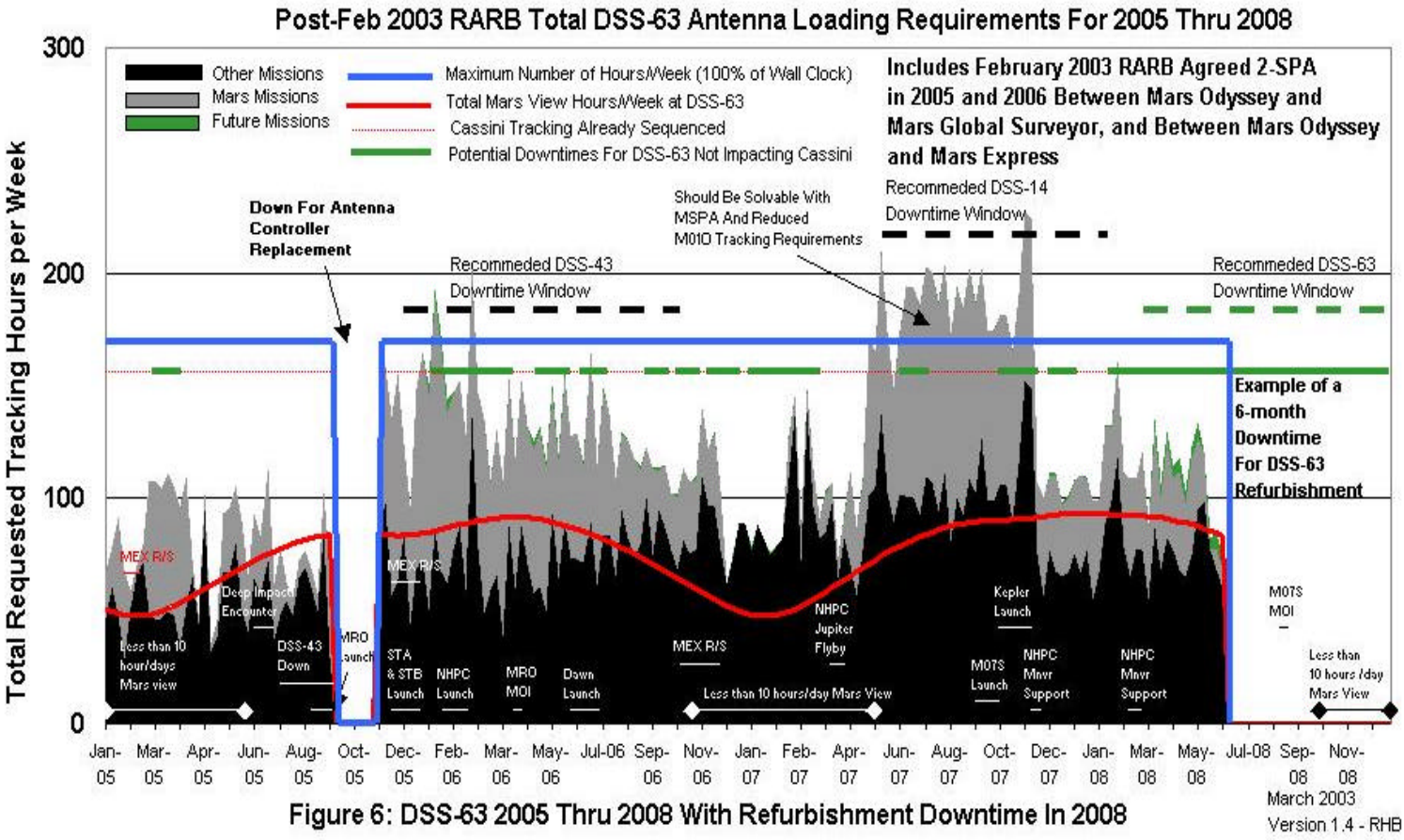

Figure 6: DSS-63 2005 Thru 2008 With Refurbishment Downtime In 2008

Conclusions

Three questions were asked in the '**Study Description**' with respect to the 70-meter life-extension project. These questions were:

1. Can the 70-meter life-extension effort be accommodated with the current projected tracking loads and critical events as they are known today?

Answer: Yes. Given tracking requirements as known today with some agreements by the projects, it is doable.

2. Will alternate assets be required when a 70-meter antenna is down for refurbishment?

Answer: Alternate assets appear not to be required.

3. Is there alternatives to taking an antenna down for a single long period of time to do the refurbishment (i.e., could the life-extension effort be done in smaller increments of downtime over a greater length of linear time that would have less impact on 70-meter availability)?

Answer: A single contiguous downtime appears to be the most efficient approach to doing the refurbishment.